

SPECIFICATION

TO ALL WHOM IT MAY CONCERN:

BE IT KNOWN THAT WE, TAKASHI KITAGUCHI, a citizen of Japan residing at Kanagawa, Japan, TOMOFUMI KITAZAWA, a citizen of Japan residing at Kanagawa, Japan and SABUROH SASAKI, a citizen of Japan residing at Tokyo, Japan have invented certain new and useful improvements in

PROJECTION-TYPE DISPLAY DEVICE AND SOFTWARE PROGRAM

of which the following is a specification:-

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## BACKGROUND OF THE INVENTION

### 1. Field of the Invention

The present invention relates to a projection-type display device, and, in particular, to a  
5 projection-type display device having a novel feature of improving a system of combining an image projected and an image drawn thereon by a user.

### 2. Description of the Related Art

10 Conventionally, generally, a projection-type display device is applied to a projector, a media board with a display device, a personal computer, etc., is used as a monitor for two or more persons in a meeting, a lecture, etc., or is used as a monitor, such as in a  
15 personal computer used individually.

Such a projection-type display device is demanded to have a feature such that letters/characters, and/or pictures may be drawn on a display device in a superimposing manner together with an image projected  
20 there, and, also, the thus-drawn letters/characters and/or pictures can be obtained as electronic data.

For this purpose, an art is proposed in which a position of a nib contacted on a display screen is detected, and is traced. However, in order to detect  
25 the position at which the nib contacts, it is necessary

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to provide a special pen with the nib. Furthermore, in order to add/erase a letter/character/picture, it is needed to appropriately change a screen operation mode. Thus, the whole system becomes expensive and operation becomes complex.

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~~Further, another art is disclosed by Japanese laid-open patent application No. 3-43726 in which an image drawn by a nib or the like on a display screen is scanned by a line-type photo-sensor, and, the thus-~~  
~~detected image is printed out. However, as the line-type photo-sensor should have a size corresponding the size of the screen, the scanner should be larger in case the size of the screen is larger. In such a case, as the scanner mechanically scans the screen, a mechanism of moving the scanner also may be of large-sized. Thus, the whole system may become bulky. Also, as the screen is scanned by the scanner mechanically, a considerable time is required to read the whole image present on the screen.~~

According to a media board disclosed in Japanese laid-open patent application No. 6-347898, while an image printed on a transparent sheet is displayed on a screen, it is possible to draw/write letters/characters/pictures thereon. Further, as a scanner scans the thus-drawn image, the scanned image

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can be easily printed out, as a hard copy. However, in this art, as the scanner mechanically scans the image present on the screen, the problems same as in the above-mentioned art may occur, i.e., the whole system  
5 may become bulky.

According to a so-called optical blackboard disclosed by Japanese laid-open patent application No. 8-160539, as a user points on a screen by a special pen, an image is projected thereon according to a locus along  
10 which the user has moved the pen on the screen through a function of a photo-sensing technology or a pressure-sensing technology. In this art, as an image is displayed on the screen as a result of the user moving the special pen on the screen and then the movement  
15 being detected by the system, the relatively complex system is needed merely for drawing an image on the screen by the user, in comparison to a case where a user draws an image directly on a screen with ink or the like by using a common ink-used pen as in a common whiteboard.

According to a media board disclosed by Japanese laid-open patent application No. 10-297166, an image drawn on a screen is read electronically, the read image data is combined with another image being projected on the screen. However, no specific  
25 configuration of how to read a drawn image is disclosed

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in the publication.

SUMMARY OF THE INVENTION

5 The present invention is directed to the above-mentioned problems, and, an object of the present invention is to provide a projection-type display device in which, as a writing surface on which a user draws/writes an image is made approximately coincident with an image projection surface, operativity is  
10 improved, the whole system is simplified, and, also, the cost needed can be effectively reduced.

Further, according to the present invention, a software program for controlling the above-mentioned projection-type display device from an external personal  
15 computer etc., is provided. Thereby, it is possible to provide the projection-type display device less costly.

According to the present invention, a projection surface is provided on which a predetermined projection image is displayed through projection; a  
20 writing surface is provided on which an image can be drawn directly in a superimposing manner with the projection image displayed on the projection surface; and a photography part is provided for photographing the image drawn on the writing surface by means of an image-  
25 pickup part comprising two-dimensionally-disposed pixels.

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Thereby, as a user can draw any image such as letters/characters/pictures on the writing surface in a manner same as in a case of a common whiteboard or blackboard, and, thus, a user-friendly system can be provided. Further, as it is possible to draw an image on the writing surface superimposing manner with the projection image displayed on the projection surface, the drawn image and projection image are combined properly on the sight of the user. Accordingly, a high-operative system can be provided.

Further, as the drawn image is photographed through an image-pickup part having two-dimensionally disposed pixels (such as a so-called digital still camera), it is easy to read the drawn image rapidly, and, also, it is not necessary to prepare a large-sized configuration to read even a large-sized image drawn on a screen. Accordingly, the whole system can be effectively miniaturized, and, thus, it becomes less costly.

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#### BRIEF DESCRIPTION OF THE DRAWINGS

Other objects and further features of the present invention will become more apparent from the following detailed description when read in conjunction with the following accompanying drawings:

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FIG. 1 shows an outline view of a projection-type display device in each embodiment of the present invention;

FIGS. 2 and 3 show an internal configuration of the projection-type display device shown in FIG. 1;

FIG. 4 shows a block diagram of a projection-type display device in a first embodiment of the present invention;

FIG. 5 shows a block diagram of a processing control part shown in FIG. 4;

FIG. 6 illustrates operations of producing a user-drawn image and a combined image according to the present invention;

FIGS. 7A and 7B illustrate two types of internal arrangement of the projection-type display device in the first embodiment of the present invention;

FIG. 8 shows a flow chart illustrating operation of the projection-type display device in the first embodiment of the present invention;

FIG. 9 shows a block diagram of a projection-type display device and a personal computer according to a second embodiment of the present invention;

FIGS. 10A and 10B illustrate a projection-type display device in a third embodiment of the present invention;

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FIG. 11 shows a block diagram of the projection-type display device in the third embodiment of the present invention;

FIG. 12 shows a flow chart illustrating operation of the projection-type display device in the third embodiment of the present invention;

FIG. 13 shows a block diagram of a projection-type display device and a personal computer according to a fourth embodiment of the present invention;

FIG. 14 illustrates a CCD and a piezoelectric device according to a fifth embodiment of the present invention;

FIG. 15 shows a block diagram of the projection-type display device in the fifth embodiment of the present invention;

FIG. 16 shows a flow chart illustrating operation of the projection-type display device in the fifth embodiment of the present invention;

FIG. 17 shows a block diagram of a projection-type display device and a personal computer according to a sixth embodiment of the present invention;

FIGS. 18 and 19 show an internal view of a projection-type display device in a seventh embodiment of the present invention;

FIG. 20 illustrates divided photography areas

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on a writing field of the projection-type display device  
in the seventh embodiment of the present invention;

FIG. 21 shows a flow chart illustrating  
operation of the projection-type display device in the  
5 seventh embodiment of the present invention;

FIGS. 22 and 23 show an internal view of a  
projection-type display device in an eighth embodiment  
of the present invention;

FIG. 24 shows a perspective view of a  
10 photography part used in the projection-type display  
device in the eighth embodiment;

FIG. 25 shows a block diagram of the  
projection-type display device according to the eighth  
embodiment of the present invention;

15 FIG. 26 shows an internal view of a  
projection-type display device in a ninth embodiment of  
the present invention;

FIGS. 27A and 27B show an internal view of a  
projection-type display device in a tenth embodiment of  
20 the present invention;

FIGS. 28A and 28B show an internal view of a  
projection-type display device in an eleventh embodiment  
of the present invention;

FIG. 29 shows an internal view of a  
25 projection-type display device in a twelfth embodiment

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of the present invention;

FIG. 30 shows a dispersion sheet and a winding roller according to the twelfth embodiment of the present invention shown in FIG. 29;

5           FIG. 31 shows an internal view of a projection-type display device in a thirteenth embodiment of the present invention;

FIGS. 32A, 32B and 32C show a dispersion sheet and winding rollers according to the thirteenth  
10           embodiment of the present invention shown in FIG. 31;  
and

FIGS. 33A, 33B and 33C show a configuration of a support board, a writing field and a transparent screen according to a fourteenth embodiment of the  
15           present invention.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Preferred embodiments of the present invention will now be described. However, respective components,  
20           specific types thereof, combinations, shapes, relative spatial arrangements, and so forth thereof which will be described are merely examples, and the present invention is not limited thereto. Further, for the same components, the same reference numerals will be given  
25           throughout the respective embodiments.

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FIG. 1 shows an appearance of a projection-type display device in a first embodiment of the present invention.

In this projection-type display device, a user  
5 can write, by using a pen 2 for writing,  
letters/characters, images, etc. on a writing field 1.  
As for the pen 2 for writing, a generally sold marker  
used for writing onto a whiteboard, such as a common pen  
employing alcoholic ink, may be used. Further, the  
10 writing field (sheet) 1 is made of material such that an  
image projected on a transparent screen 6 (see FIG. 2)  
provided on the side opposite to the user side can be  
sufficiently transmitted thereby. Thereby, the user can  
view an image projected on the transparent screen 6 by a  
15 projector 4 (see FIG. 2) through the writing field 1.  
In addition, such a treatment is made on a surface of  
the writing field 1 on which writing is made by the user  
that an image drawn thereon by ink may be easily erased  
by a cloth or the like, as in a common whiteboard.  
20 The projection-type display device is enclosed  
by a housing 3 such that, as shown in FIG. 3,  
particularly a zone through which a light beam 41 passes  
from the projector 4 to the screen 6 is enclosed thereby.  
Further, switches 11 which provide functions as a user  
25 interface are provided on the housing 3, and, thereby,

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the user can freely control various conditions in the projector 4 and a CCD (Charge Coupled Device) camera 7, such as image display conditions, image-pickup conditions, and so forth.

5           FIG. 2 shows an inside rear view of the projection-type display device in the first embodiment while FIG. 3 shows an inside side view of the same.

10           The projector 4 projects an image onto the transparent screen 6 through a reflective mirror 5. The transparent screen 6 is provided inside with respect to the writing field 1. In this configuration, since the field 1 is transparent, the user can view the projected image through the writing field 1 from the outside.

15           Further, an image written/drawn onto the writing field 1 by the user can also be viewed from the inside of this projection-type display device through the transparent writing field 1 and the transparent screen 6. Therefore, the CCD camera 7 provided inside of the display device can take a picture of the image  
20           written/drawn on the writing field 1. In the first embodiment, the CCD camera 7 takes a picture of an image written on the writing field 1 also through the reflective mirror 5.

25           Furthermore, by a processing control part 8 (see FIG. 4) provided inside of the display device,

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predetermined processing is performed, and an image electronically taken in by the CCD camera 7 is output to the outside through an input-and-output part 9 (see FIG. 4) also provided in the display device.

5           In addition, the projector 4, reflective mirror 5, and transparent screen 6 mainly act as a projection part, while the CCD camera 7, writing field 1 and reflective mirror 5 mainly act as a photography part. Further, the switches 11 mainly act as a mode selection  
10 part.

          According to a basic feature of the projection-type display device described above, this display device is superior in terms of user interface. With the same feeling as in a common blackboard or  
15 whiteboard, the user can draw letters/characters, line drawings, etc. onto the writing field 1. Further, the user can change photography (picture taking) processing modes, described later, easily.

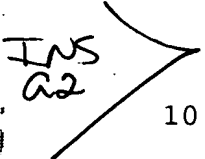
          Further, according to the first embodiment,  
20 preferably, an image projected onto the transparent screen 6 and an image taken in from the writing field 1 can be used independently. For this purpose, preferably, the projection-type display device is configured such that the image projected and the image taken in are  
25 taken independently. Furthermore, preferably, the

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surface on which an image is projected (transparent screen 6) and a surface on which an image is drawn (writing field 1) are made approximately coincident.

Thereby, a taken-in drawn image can be easily

5 superimposed on a projected image through the sight of the user. Thereby, the projection-type display device excellent in operativity and functionality can be provided.

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a2*  ~~With reference to FIG. 4, a block~~  
10 ~~configuration of the projection-type display device in the first embodiment will now be described in detail.~~

In FIG. 4, the processing control part 8 performs control of the CCD camera 7 and projector 4 based on signals from the switches 11. Furthermore, the  
15 processing control part 8 executes a software program read from a storage part 10 with using a work area in the storage part 10 appropriately, and also executes a function of extracting an image drawn by the user from an image taken in through the CCD camera 7 as shown in  
20 FIG. 5.

Further, the processing control part 8 produces an image (combined image) in combination of an image displayed onto the projector 4 and an image (user-drawn image) drawn by the user and taken in by the CCD  
25 camera 7. Furthermore, the processing control part 8

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also controls processing of storing the user-drawn image and the above-mentioned combined image in the storage part 10, and processing of outputting them to the outside through the input-and-output part 9.

5           The input-and-output part 9 performs processing of inputting, into the internal processing control part 8 and into the internal projector 4, image signals outputted from an external personal computer etc., and processing of outputting the user-drawn image  
10 and combined image output from the processing control part 8 to the outside. In addition, this input-and-output part 9 includes I/O interfaces, such as a USB (Universal Serial Bus) interface, an IEEE1394 interface, and a SCSI (Small Computer System Interface), and/or  
15 includes an interface with a video card in an external apparatus, such as a PC.

          The switches 11 are used for controlling ON/OFF of the projector 4, input of user's instructions for taking a picture of user-drawn image by the CCD  
20 camera 7, and selection between two types of photography processing modes.

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25           ~~These two types of photography processing~~  
          <sup>23</sup> modes will now be described. The first photography processing mode is a mode of operation for extracting and ~~acquiring only the above-mentioned user-drawn image,~~

and a second photography processing mode is a mode of operation for acquiring the above-mentioned combined image in which the user-drawn image and projection image are combined. These two photography processing modes are executed as a result of the processing control part 8 reads a predetermined software program from the storage part 10, as shown in FIG. 5.

As shown in FIG. 5, the processing control part 8 includes an image reversal part 81 which reverses right and left of an image of an image signal input from the CCD camera 7, a user-drawn extraction part 82 which extracts a user-drawn image from the thus-reversed image, and an image combining 83 which combines the user-drawn image with a projection image. Further, in this configuration, the image signal provided by the user-drawn extraction part 82 or the image combining part 83 is stored by the storage part 10, is input into the projector 4 through the processing control part 8, or is output to an external apparatus through the input-and-output part 9.

With reference to FIG. 6, the operation according to the first photography processing mode will now be described. When the first photography processing mode is selected through the switches 11 by a user, the processing control part 8 causes the CCD camera 7 to

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take a picture of the writing field 1. Thereby, a photographed image I1 in which right and left are reversed as shown in FIG. 6 is acquired as a result of the picture was taken through the reflective mirror 5 shown in FIG. 3. Then, the processing control part 8 provides a reversal image I2 by reversing the right and left of the photographed image I1 through the image reversal part 81.

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Furthermore, the processing control part 8 causes the image extraction part 82 to extract a user-drawn image I4 from the reversal image I2. This extraction is achieved as a result of the reversal image I2 having a reference image I3 previously taken at a state in which nothing is drawn in the writing field 1 and then reversed between right and left thereof subtracted therefrom. Thereby, any images, other than the user-drawn image currently drawn by user, such as cracks or the like of the transparent screen 6, are removed. Then, the user-drawn image I4 is stored by the storage part 10, for example, or is output to the external apparatus through the input-and-output part 9.

Similarly operation in the second photography processing mode will now be described with reference to FIG. 6. When the second photography processing mode is selected through the switches 11 by the user, the

processing control part 8 extracts the user-drawn image I4 from the photographed image I1 obtained through the CCD camera 7, as in the case of the first photography mode. After the user-drawn image I4 is stored by the  
5 storage part 10 temporarily, it is input into the image combining part 83. Then, a projection image I5 currently stored in the storage part 10 is also input into the image combining part 83. Then, the image combining part 83 combines the user-drawn image I4 and  
10 the projection image I5 together, and outputs the combined image I6.

As for the user-drawn image I4 and the projection image I5, correspondence therebetween is made by the processing control part 8. That is, the  
15 projection image projected when the user-drawn image is taken by the CCD camera 7 in response to the operation made onto the switches 11 is made to have a correspondence to this user-drawn image. For this purpose, the processing control part 8 stores the  
20 projection image I5 together with the user-drawn image I4 in a manner of making correspondence therebetween into the storage part 10. Thereby, it is possible to take these images together easily in future. Further, the combined image I6 is stored by the storage part 10,  
25 for example, or is output to the external apparatus

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through the input-and-output part 9.

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~~Further, since the projector 4 and CCD camera 7 uses the approximately same surface (the writing field 1 and transparent screen 6), as shown in FIG. 7A, it is~~  
5 ~~easy to combine the user-drawn image I4 obtained from the photographed image I1 with the projection image I5 by making the optical axis of the CCD camera 7~~  
~~coincident with a center axis 60 of the writing field 1, the center axis 60 being perpendicular to the writing~~  
10 ~~field 1.~~

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However, in the example shown in FIG. 7A, for the sake of simplification of illustration, the reflective mirror 5 is omitted. In case the CCD camera 7 is disposed on the center axis 60 of the writing field 6 as shown in the figure, it is necessary to make the  
15 optical axis of the projector 4 to be inclined as shown in FIG. 7A. Such inclination of the optical axis can be achieved by using a well-known function of a common projector.

20 Further, in case where the projector 4 is disposed on the center axis 60 of the writing field 1 as shown in FIG. 7B, although it is not necessary to incline the optical axis of the projector 4 as mentioned above, it is necessary to perform tilt correction on a  
25 photographed image acquired by the CCD camera 7. Such a

tilt correction can be performed according to a well-known common way, and, in this embodiment, the processing control part 8 performs tilt correction on the photographed image 11..

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~~Furthermore, in the embodiment, projection of an image by the projector 4 may be interrupted during the user-drawn image is pick up by the CCD camera 7. Thereby, it can be prevented that the projection image becomes obstructive to the photography of the user-drawn image, and, thereby, the user-drawn image cannot be extracted properly. Further, in addition to this, the photographed image which also contains the projection image may be acquired by the CCD camera 7, and, then, the projection image may be subtracted from the~~  
10  
15 ~~photographed image (reversal image).~~

The storage part 10 mainly includes a recording part, and the input-and-output part 9 mainly includes an input part and an output part. The image projected by the projector 4 and the image photographed by the CCD camera 7 may be appropriately processed by an external personal computer, or the like. For this purpose, the storage part 10 which once stores the image and the input-and-output part 9 which transmits the data to the external personal computer are needed.

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~~Further, the image projected by the projector~~  
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4 ~~may be of image data processed in by the external~~  
apparatus, or the photographed projection image itself.  
Therefore, the input-and-output part 9 is also needed.  
Thereby, a selected image can be recorded in the above-  
5 mentioned storage part 10 or it can be transmitted to  
the external apparatus through the above-mentioned  
input-and-output part 9, and, thus, it becomes easier to  
perform image data processing by using the external  
processing apparatus.

10           Operation of the processing control part 8 in  
the first embodiment will now be described with  
reference to FIG. 8. In response to a signal coming  
from the switches 11 indicating photography (Yes of a  
step S101), the processing control part 8 sends  
15 instructions such that an image on the writing field 1  
be taken by the CCD camera 7 (in a step S102), and then,  
the processing control part 8 receives a photographed  
image therefrom (in a step S103). At this time, the  
light source in the projector 4 may be turned off, as  
20 mentioned above.

Then, the processing control part 8 produces  
the user-drawn image I4 or combined image I6 according  
to the process shown in FIG. 6 (in a step S104). The  
user-drawn image or combined image thus produced is  
25 stored by the storage part 10, or is output to the

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external apparatus through the input-and-output part 9.

*INS*  
*as* ~~Thereby, the projection-type display device~~  
~~which can acquire easily information input through~~  
~~handwriting/drawing by the user as image information.~~

5                   In the above-described first embodiment,  
processing such as control of the projector 4, CCD  
camera 7, switches 11, reversal of a photographed image  
obtained by the CCD camera 7, image extraction, image  
combining, etc. is performed by the processing control  
10 part 8 provided inside of the projection-type display  
device. According to a second embodiment of the present  
invention, as will now be described, this processing is  
performed by an external apparatus, such as a personal  
computer, instead.

15                   According to the second embodiment, as shown  
in FIG. 9, the projector 4, CCD camera 7 and switches 11  
are connected to a personal computer 108 provided inside  
or outside of a projection-type display device as shown  
in FIG. 9. USB, IEEE1394, SCSI, etc. are applied as the  
20 interface for connecting these respective components.  
Driver software (a CCD camera driver 1081, a projector  
driver 1082, and a switch driver 1083) for controlling  
the CCD camera 7, projector 4, and switches 11 is  
installed in the personal computer 108, and, thereby,  
25 control of each component, and input and output of

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various instructions and/or data therefrom/thereto are performed.

Thus, according to the second embodiment, the configuration of the projection-type display device is simplified, and, also, a predetermined software provides various control processing needed. Thereby, the projection-type display device can be provided at low cost.

Since the other configurations and operations are the same as those of the first embodiment, duplicated description is omitted.

According to the second embodiment, the function of the processing control part 8 in the first embodiment is achieved directly by the CPU (central processing unit) included in the personal computer 108.

A projection-type display device in a third embodiment of the present invention will now be described. FIGS. 10A and 10B illustrate an inner structure of the projection-type display device in the third embodiment.

According to the above-mentioned first embodiment, when the light source in the projector 4 is turned off in order to prevent floodlighting of the projector 4 from being applied in photographing a user-drawn image formed on the writing field 1 by the CCD

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camera 7, a considerable time is taken for again starting up the floodlighting for image projection by the projector 4, and, also, the life of the power supply thereof may be shortened through repetitive turning on/off thereof. In order to avoid such a situation, as shown in FIGS. 10A and 10B, a light-blocking plate 21 for blocking the light beam emitted from the projector 4 is provided in the third embodiment of the present invention..

10 In the configuration of the third embodiment, the light-blocking plate 21 is removed and thus, the transparent screen 6 can have an image projected thereunto from the projector 4 at a time of image projection, as shown in FIG. 10A. On the other hand, at 15 a time of photography of a user-drawn image formed on the writing field 1, the light-blocking plate 21 is placed in front of the projector 4, and thereby, the light beam emitted by the projector 7 is prevented from reaching the transparent screen 6, as shown in FIG. 10B. 20 Removing and inserting of the light-blocking plate 21 mentioned above is performed by using a stepper motor 22, or the like which is driven and controlled by the processing control part 8.

FIG. 11 is a block diagram showing a 25 configuration of the projection-type display device in

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the third embodiment. Thus, different from the above-mentioned first embodiment, the projection-type display device according to the third embodiment includes the stepper motor 22, and the processing control part 8  
5 controls the stepper motor 22, and thus controls removing and inserting of the light-blocking plate 21 appropriately from/to the front side of the projector 4

As described above, the first or second  
10 photography processing mode is the mode in which an image which a user draws onto the writing field 1 is photographed by the CCD camera 7. However, if a projection image formed by the projector 4 is present on the transparent screen 6, the user-drawn image formed on the writing field 1 may not be photographed clearly.  
15 This is because a halogen lamp is generally used as the light source of the projector 4, and, thus, it may be difficult to clearly photograph the user-drawn image superimposed on the projection image in terms of brightness and luminous energy.

20 Then, it is desirable at a time of the first or second photography processing mode to prevent the image from being projected by the projector 4. Since the light beam emitted by the projector 4 is thus blocked by the light-blocking plate 21 at a time of the  
25 first or second photography mode according to the third

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embodiment, the user-drawn image on the writing field 1 can be photographed independently and clearly.

Operation of the processing control part 8 according to the third embodiment will now be described with reference to FIG. 12. The processing control part 8 drives the stepper motor 22 so as to make the light-blocking plate 21 be inserted, and, thus, block the light beam emitted by the projector 4 (Step S202), when a signal is inputted from the switches 11 (Yes of a step S201). Then, after the light beam from the projector 4 is blocked, the processing control part 8 controls the CCD camera 7 so as to cause it to photograph the image on the writing field 1 (in a step S203), and acquires the thus-photographed image (in a step S204). At this time, the light source of the projector 4 is not turned off.

Then, the processing control part 8 produces the user-drawn image or combined image according to processing shown in FIG. 6 from the photographed image acquired in the step S204 (in a step S205). Then, the user-drawn image or combined image thus generated by is stored as mentioned above in the storage part 10, or is output to the external apparatus from the input-and-output part 9.

Then, after acquiring the photographed image

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in the step S204, the processing control part 8 drives the stepper motor 22 so that the light-blocking plate 21 may be removed and allows the projection image to be displayed on the transparent screen 6 (in a step S206).

5 Thus, according to the third embodiment, since the photographed image can be obtained in a condition in which the light beam from the projector 4 is prevented from reaching the transparent screen 6 without turning off of the light source of the projector 4, the life of  
10 the projector 4 can be prevented from being superfluously shortened.

Since the other configurations and operations are the same as those of the first embodiment, duplicated description is omitted.

15 The above-mentioned third embodiment may also be configured by utilizing a personal computer or the like together with software programs as the above-mentioned first embodiment is modified into the second embodiment, as in a fourth embodiment of the present  
20 invention. FIG. 13 shows a block diagram of this fourth embodiment of the present invention. This block configuration is the same as that of the second embodiment shown in FIG. 9 except that the stepper motor 22 and a stepper motor driver 1084 (application  
25 software) are added. All the functions/operations of

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the fourth embodiment are the same as those of the third embodiment, and duplicated description is omitted.

A fifth embodiment of the present invention will now be described. FIG. 14 illustrates a CCD 31  
5 provided inside of the CCD camera 7.

When photographing an image present on the writing field 1 by the CCD camera 7, the resolution poses a problem. In order to increase the resolution in photography by the CCD camera 7, according to the fifth  
10 embodiment, pixel shifting function is applied. Thereby, the writing field 1 is photographed twice, and, at this time, the CCD 31 shown in FIG. 14 is shifted by a distance corresponding to predetermined pixels (for example, one pixel) vertically or horizontally. Thereby,  
15 the resolution along the direction in which the CCD 31 is thus shifted can be increased double. By increasing the number of times of photography with the pixel shift each time, i.e., by 3 times, 4 times, ..., the resolution is increased by 3 times, 4 times, ..., accordingly.

In the example shown in FIG. 14, when  
20 photographing the writing field 1 in 2 steps with the CCD camera 7, the photography area is shifted by a distance for one pixel vertically. In order to embody a mechanism of shifting the CCD 31 as mentioned above, a  
25 piezoelectric device drive circuit 33 which drives a

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piezoelectric device 32 based on a signal given by the processing control part 8 may be employed for example.

The thus-obtained two pixel-shifted photographed images are input into the processing control part 8, and are combined together. Specifically, the combined image is obtained as a result of the pixels on the two images are arranged alternately one by one. According to the fifth embodiment, it is possible to effectively improve the resolution of the photographed image without increasing the pixels of the CCD 31 itself.

However, the number of pixels by which the shift is made and the direction of the shift are not limited. For example, the writing field 1 may be divided into division areas, and, each division area is photographed by the CCD camera 7 by shifting the photography area of the camera 7 as mentioned above. Further, a user may select whether or not such shift function is applied, through the switches 11.

FIG. 15 is a block diagram showing a configuration of the fifth embodiment. A different point of the projection-type display device in the fifth embodiment from the above-mentioned third embodiment is that the piezoelectric device drive circuit 33 is added, the processing control part 8 controls the piezoelectric device drive circuit 33, and the CCD 31 is thereby

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mechanically moved by (distance corresponding to) 1 pixel, as mentioned above.

Generally many electric charge accumulation type CCD elements are used in the CCD camera 7. Many  
5 pixels are regularly arranged by unit area, and the CCD element accumulates the electric charge according to luminous energy irradiated there, and carries out photoelectric transform. Therefore, when it shifts by 1 pixel, a photograph is taken and the image data is  
10 combined afterwards when photographing a fixed area twice, it is possible to obtain a photograph same as that obtained by the double recording density. According to the fifth embodiment, for this reason, the resolution of the photographed image is improved twice.  
15 Further, by employing the piezoelectric device called a piezoelectric vibrator, it is possible to shift the CCD precisely by one pixel as the piezoelectric device has a mono-crystal formation and vibrates at a peculiar pitch as well-known.

20 Operation of the processing control part 8 according to the fifth embodiment will now be described with reference to FIG. 16. The processing control part 8 drives the stepper motor 22 so as to make the light-blocking plate 21 be inserted, and, thus, block the  
25 light beam emitted by the projector 4 (Step S302), when

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a signal is inputted from the switches 11 (Yes of in a step S301). Then, after the light beam from the projector 4 is thus blocked, the processing control part 8 controls the CCD camera 7 so as to cause it to photograph the image on the writing field 1 (in a step S303), and acquires the thus-photographed image (in a step S304). At this time, the light source of the projector 4 is not turned off.

Then, the processing control part 8 moves the CCD 31 through the piezoelectric device drive circuit 33 by 1 pixel by means of the piezoelectric device 32 (in a step S305), and then controls the CCD camera 7 to take a photograph similarly (in a step S306), and acquires the thus-photographed image (in a step S307). Then, when the two photographed images shifted by 1 pixel are thus acquired, the processing control part 8 returns the CCD 31 to the original position by returning the piezoelectric device 32 to the original state through the piezoelectric device drive circuit 33 (in a step S308).

Then, the processing control part 8 combines the thus-obtained two photographed images (in a step S309). Then, the processing control part 8 produces the user-drawn image or combined image according to processing shown in FIG. 6 from the pixel combined image

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acquired in the step S309 (in a step S310). Then, the user-drawn image or combined image thus generated is stored as mentioned above in the storage part 10, or is output to the external apparatus from the input-and-  
5 output part 9.

Then, after acquiring the photographed image in the step S307, the processing control part 8 drives the stepper motor 22 so that the light-blocking plate 21 may be removed (in a step S311).

10 In addition, the user-drawn image or the combined image generated by this is stored as mentioned above in the storage part 10, or is output to the external apparatus from the input-and-output part 9.

Accordingly, it is possible to obtain high-  
15 resolution image without increasing the physical number of pixels on the CCD 31. Since the other configurations and operations are the same as those according to the third embodiment, duplicated description is omitted.

The above-mentioned fifth embodiment may also  
20 be configured by utilizing a personal computer or the like together with software programs as the above-mentioned first embodiment is modified into the second embodiment, as in a sixth embodiment of the present invention. FIG. 17 shows a block diagram of this sixth  
25 embodiment of the present invention. This block

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configuration is the same as that of the fourth  
embodiment shown in FIG. 13 except that the  
piezoelectric device drive circuit 33 is controlled by  
the above-mentioned CCD camera driver 1081. All the  
5 functions/operations of the sixth embodiment are the  
same as those of the fifth embodiment, and duplicated  
description is omitted.

A seventh embodiment of the present invention  
will now be described. FIGS. 18 and 19 illustrate an  
10 internal configuration of a projection-type display  
device in the seventh embodiment of the present  
invention. As shown in the figures, a plurality of CCD  
cameras 7 (four sets in the configuration shown in FIG.  
18) are provided. The writing field 1 is divided into  
15 four areas A, B, C and D, as shown in FIG. 20  
corresponding to the respective photography areas of the  
CCD cameras 7A, 7B, 7C and 7D. Thereby, as a result of  
the CCD cameras 7A through 7D photographing the  
respective areas A through D, and the thus-obtained  
20 photographed images being combined by the processing  
control part 8, it is possible to take a photograph at  
high resolution. Thereby, the user-drawn image at high  
resolution can be obtained.

Generally, the resolution of an image is  
25 determined by a mutual relationship between the

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photography area and number of pixels of a CCD camera used. That is, when photographing a same area, resolution becomes higher as the area photographed is smaller. According to the seventh embodiment, since the  
5 above-mentioned writing field 1 is divided into the four areas, and the respective areas are photographed simultaneously by the four CCD cameras, the resolution of an image taken by each CCD camera can be made higher accordingly.

10 ~~Further, according to the seventh embodiment,~~  
~~whether or not such a dividing photography manner is applied may be preferably determined by a user according to an intention of the user and/or an image formed on the writing field 1. Thereby, when the user-drawn image~~  
15 ~~is relatively simple one, and, or when the user does not wish such a dividing photography way for some reasons, the dividing photography manner may not be applied, and a normal photography such that merely the full area or a predetermined area of the writing field 1 is~~  
20 ~~photographed by the single CCD camera 7.~~

25 ~~Furthermore, more preferably in terms of functions, the number of division in case of the dividing photography may be determined by a user. Instructions as to whether or not the dividing photography mode is selected, and the number of division~~

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therein may be input through the switches 11. According to the seventh embodiment, operativity and functionality are improved.

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5 operation of the processing control part 8 according to the seventh embodiment will now be described with reference to FIG. 21. The processing control part 8 drives the stepper motor 22 (in a step S402) so that the light-blocking plate 21 be inserted when a signal is input from the switch 11 (Yes of in a 10 step S401). Then, after the light beam emitted from the projector 4 is thus blocked, the processing control part 8 determines whether instructions for the dividing photography have been input from the switches 11 (in a step S403). Preferably, as mentioned above, which one 15 of the dividing photography areas is photographed, how many divisions the photography area is divided, and so forth may be input at the same time by the user.

When instructions for the dividing photography have not been input in the step S403 (No in the step 20 S403), the processing control part 8 sends instructions to the CCD camera of the CCD cameras 7A through 7D which can photograph the entire area of the writing field 1 (for example, a configuration is made such that the CCD camera 7A can do so) (in a step S404), and acquires the 25 photographed image therethrough (in a step S405).

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On the other hand, when instructions for the dividing photography have been input in the step S403 (Yes in the step S403), the processing control part 8 sends instructions to CCD cameras (any ones of those 7A through 7D) corresponding to the number of photography area divisions, specific photography areas, and so forth according to the instructions (Step S406), and acquires all the photographed images thus taken (in a step S407).

Further, the processing control part 8 combines these photographed images acquired according to a predetermined arrangement of the photography areas on the CCD cameras 7, and thus produces one combined photographed image (in a step S408).

Then, the processing control part 8 produces the user-drawn image or combined image according to processing shown in FIG. 6 from the combined image acquired in the step S408 (in a step S409). Then, the user-drawn image or combined image thus generated is stored as mentioned above in the storage part 10, or is output to the external apparatus from the input-and-output part 9.

Then, after acquiring the photographed image in the step S405 or S407, the processing control part 8 drives the stepper motor 22 so that the light-blocking plate 21 may be removed (in a step S410).

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In addition, the user-drawn image or the combined image generated is stored as mentioned above in the storage part 10, or is output to the external apparatus from the input-and-output part 9.

5           Thereby, all or a part of the user-drawn image is acquirable in the resolution suitable for the demand of the user. Since the other configurations and operations are the same as those of the third embodiment, duplicated description is omitted.

10           The above-mentioned seventh embodiment may also be configured by utilizing a personal computer or the like together with software programs as the above-mentioned first embodiment is modified into the second embodiment. However, in this case, the CCD driver 1081  
15 in the personal computer 108 is configured such that the driving control of the plurality of CCD cameras (7A through 7D) can be carried out thereby.

          An eighth embodiment of the present invention will now be described. FIGS. 22 and 23 illustrate an  
20 internal configuration of a projection-type display device in the eighth embodiment of the present invention.

          In the eighth embodiment, a photography part 51 having pan/tilt functions performs photography on the writing field 1. FIG. 24 shows a perspective view of  
25 the photography part 51. The photography part 51 has a

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CCD camera 7 and a shaking mechanism the 52, and can control the photography area of the CCD camera 7 through the shaking mechanism 52 together with a well-known zoom function of the CCD camera 7.

5 A user may give instructions to the projection-type display device to indicate a desired part of the writing field 1 by operating the photography part 51 using some of the switches 11. At this time, the projector 4 displays a currently set photography  
10 area of the CCD camera 7 on the transparent screen 6, as shown in FIG. 22. Thereby, the user can control the photography area with checking the actually set area simultaneously.

FIG. 25 is a block diagram showing a  
15 configuration of the projection-type display device in the eighth embodiment. Different points of the projection-type display device from the projection-type display device in the above-mentioned fifth embodiment are that the shaking mechanism 52 is used instead of the  
20 piezoelectric device drive circuit 33, and also, a fluorescent light 53 for front lighting is added.

Based on user' instructions from the switches 11, the processing control part 8 performs control of the photography part 51. Further, in case high  
25 resolution photography is performed, the shaking

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mechanism 52 may be used. Namely, the writing field 1 is divided and photographed by a part-by-part manner, the thus-obtained partial photographed images are combined/collected/joined so that a high-resolution photography image is obtained. This dividing photography is achieved by appropriately controlling the optical axis of the CCD camera 7 through the above-mentioned tilt and pan functions of the shaking mechanism 52. The user can select either the dividing photography mode or the normal mode in which a photography image is obtained through a single photography operation without dividing the writing field 1, by using the switches 11. Further, the user may also select the number of divisions of the writing field 1 in the case of dividing photography mode, also through the switches 11.

The dividing photography is achieved by using the plurality of CCD cameras 7A through 7D according to the above-mentioned seventh embodiment, which needs costs for the number of CCD cameras. In contrast thereto, according to the eighth embodiment, only the single CCD camera 7 does the same through changing the optical axis thereof appropriately, which thus needs less costs. Thus, according to the eighth embodiment, the projection-type display device excellent in

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operativity and functionality can be provided at low costs.

Furthermore, this projection-type display device in the eighth embodiment is configured such that  
5 a storage area in the storage part 10 may be determined according to the angle of the CCD camera 7 in connection with the operation of the shaking mechanism 52.

Further, since the other configurations and operations are the same as those of the seventh embodiment, duplicated description is omitted.

10 ~~A ninth embodiment of the present invention~~  
*INS*  
*a-13*  
will now be described. FIG. 26 illustrates the projection-type display device in the ninth embodiment. An image on the writing field 1 is photographed by the  
15 CCD camera 7 provided inside of the projection-type display device. Therefore, the image on the writing field 1 can be photographed more effectively in a condition in which the image is illuminated from the user side or outside. That is, as shown in the figure, according to the present embodiment, a lighting 54  
20 illuminates the writing field from the user side (~~outside of the projection-type display device~~).

Thereby, since the writing field 1 is illuminated from the side opposite to the projector 4,  
25 the efficiency of lighting is improved, and a

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photographed image becomes brighter. However, if the light from the lighting 54 is irradiated directly to the user, the user's visibility may be degraded accordingly. Then, in this embodiment, a lampshade 55 is provided  
5 such that the light from the lighting 54 may be prevented from directly irradiating the user. The other configurations and operations of the ninth embodiment are the same as those of the first embodiment, and duplicated description is omitted.

10 A tenth embodiment of the present invention will now be described. FIGS. 27A and 27B illustrate an inside configuration of a projection-type display device in the ninth embodiment. FIG. 27A illustrates a light beam 41 emitted from the projector 4, while FIG. 27B  
15 illustrates a light beam 42 emitted from a lighting 54. If some obstacle were present along the path of the light beam 41 from the projector 4 toward the transparent screen 6, an image of the obstacle would be displayed on the transparent screen 6 which would be  
20 then photographed by the CCD camera 7 problematically.

Therefore, it is necessary to locate the lighting 54 out of the path of the light beam 41 from the projector 4 toward the transparent screen 6. Thus, since the lighting 55 illuminating the writing field 1  
25 from the side of the projector 4 is located out of the

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path of the light beam 41 from the projector 4 according to the present embodiment, it does not have a bad influence on the projection image from the projector 4, and, also, the entire display device can be made smaller.

5                However, if the light from the lighting 54 irradiated directly the CCD camera 7, a photographed image taken by the CCD camera 7 would fade white. Then, according to the tenth embodiment, a lampshade 55 is provided in such a manner that the light from the  
10              lighting 54 may not directly irradiate the CCD camera 7.

                The other configurations and operations of the tenth embodiment are same as those of the first embodiment, the duplicated description is omitted.

                An eleventh embodiment of the present  
15              invention will now be described. FIGS. 28A and 28B illustrate an inside configuration of a projection-type display device in the eleventh embodiment. FIG. 28A illustrates respective light beams 42 from lightings 56 and 57, while FIG. 28B illustrates the light beam 41  
20              from the projector 4.

                The writing field 1 should be illuminated brightly as much as possible, and also, the illumination should be made uniformly. Therefore, according to the eleventh embodiment, the lightings 56 and 57 are  
25              provided in symmetrical positions with respect to an

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axis 58 corresponding to the optical axis of the projector 4, thereby the homogeneity in brightness on the writing field 1 being improved effectively.

Thus, according to the eleventh embodiment, since on the side of the projector 4, the lightings 56 and 57 are provided for illuminating the writing field 1 approximately symmetrically with respect to the axis 58 corresponding to the optical axis of the projector 4, it does not have a bad influence on a projection image from the projector 4, brightness thereon becomes uniform, and the unevenness on the image is eliminated.

However, if the light from the lightings 56 and 57 irradiated directly the CCD camera 7, a photographed image taken by the CCD camera 7 would fade white accordingly. Then, according to the eleventh embodiment, lampshades 55 are provided such that the light from the lightings 56 and 57 may not directly irradiate the CCD camera 7.

The other configurations and operations are same as those of the first embodiment, and duplicated description is omitted.

A twelfth embodiment of the present invention will now be described. FIG. 29 illustrates an internal configuration of a projection-type display device in the twelfth embodiment. As in a common screen used for an

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OHP, the color of the transparent screen 6 is gray. Accordingly, without particularly illuminating it, it is hard to clearly view an image drawn thereon. That is, when using the transparent screen 6 as a whiteboard, such a problem may occur. Then, according to the twelfth embodiment, an opaque white dispersion sheet 23 may be inserted between the writing field 1 and transparent screen 6.

When using the projection-type display device as a simple display device, the dispersion sheet 23 may be removed to a position such that it may not be obstructive by a winding mechanism. That is, the dispersion sheet 23 can be removed/inserted through pulling members 25 and a winding roller 24, as shown in the figure. It is noted that, in this embodiment, a configuration is made such that the writing field 1 and transparent screen 6 are pressed onto one another forcibly. Therefore, while being pressed by both of the writing field 1 and transparent screen 6, the dispersion sheet 23 is pulled out/inserted in by the pulling members 25/winding roller 24. Thereby, the dispersion sheet 23 is prevented from twisting or bending between the writing field 1 and transparent screen 6, but can be maintained in a plane state.

FIG. 30 illustrates an example of

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configuration of the above-mentioned dispersion sheet 23,  
pulling members 25 and winding roller 25 together with a  
winding crank handle 61. As shown in the figure, the  
pulling members (ropes) 25 are provided at both ends of  
5 the dispersion sheet 23, and thereby, the dispersion  
sheet 23 can be pulled without right-and-left unbalance  
in pulling force. Further, the rotation shaft of the  
winding roller 24 is connected with the winding crank  
handle 61 provided outside of the projection-type  
10 display device. Thereby, the winding roller 24 can pull  
the dispersion sheet 23 without right-and-left unbalance.

According to the twelfth embodiment, the  
opaque white dispersion sheet 23 is provided on the rear  
side of the writing field 1 with respect to the user.  
15 Thus, the writing field 1 can also be used as a  
whiteboard satisfactorily, and thus, a usage scope of  
the projection-type display device can be effectively  
widened.

Since the other configurations and operations  
20 of the twelfth embodiment are the same as those of the  
first embodiment, duplicated description is omitted.

A thirteenth embodiment of the present  
invention will now be described. FIG. 31 illustrates an  
inner configuration of a projection-type display device  
25 in the thirteenth embodiment. This projection-type

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display device also includes an opaque white dispersion  
sheet 23 which may be inserted between the writing field  
1 and transparent screen 6 in a state such that the  
dispersion sheet 23 is pressed from both of the writing  
5 field 1 and transparent screen 6.

FIGS. 312A, 32B and 32C illustrate a  
configuration of the dispersion sheet 23 in the  
thirteenth embodiment together with winding rollers 24  
and a winding crank handle 61. The dispersion sheet 23  
10 includes a sufficiently transparent area 62 as shown in  
FIG. 32C to make an image projected on the transparent  
screen 6 visible by the user present outside of the  
display device. The transparent area 62 has a  
sufficiently large area such that a predetermined image  
15 projected by the projector 4 can be satisfactorily seen  
from the user. Further, the opaque white area of the  
diffusion sheet 23 other than the above-mentioned  
transparent area 62 also has a sufficiently large area  
such as to be able to cover the entire writing field 1,  
20 as shown in FIG. 32A.

Further, the dispersion sheet 23 (transparent  
area 62 is included therein) has top and bottom portions  
thereof wound by the rolling rollers 24, respectively,  
and can be moved arbitrarily through a winding crank  
25 handle 61 connected with the lower winding roller 24, as

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shown in the figures. That is, the winding crank handle 61 provided outside of the display device is connected with a rotation shaft of the lower winding roller 24, as in the above-mentioned twelfth embodiment. Furthermore, 5 the upper and lower rolling rollers 24 are connected by a timing belt together such that these rollers rotate in synchronization with one another in the same direction. Thereby, the dispersion sheet 23 is rolled without right-and-left unbalance, and it becomes possible to 10 move the transparent area 62 up and down arbitrarily. In addition, the above-mentioned transparent area 62 is thus movable upward or downward so that this area 62 may not overlap the writing field 1 at all, as shown in FIG. 32A.

15 According to the thirteenth embodiment, the opaque white dispersion sheet 23 can be inserted on the rear surface of the writing field 1 with respect to the position of the user as mentioned above, and thus, this display device can be satisfactorily used as a 20 whiteboard and thus, the usage scope of the projection-type display device can be effectively widened.

Since the other configurations and operations are the same as those of the first embodiment, duplicated description is omitted.

25 A fourteenth embodiment of the present

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invention will now be described. According to any of the above-mentioned embodiments, in case the writing field 1 does not have a sufficiently structural strength such as to maintain the plane state during a

5 drawing/writing operation performed by a user thereon with the pen 2 as shown in FIG. 1, an additional support board may be provided between the writing field 1 and transparent screen 6 or on the side of the transparent screen 6 opposite to the side of the writing field 1, for reinforcing the writing field 1, according to the  
10 fourteenth embodiment.

*INS  
a-14* *FIGS. 33A and 33B illustrate the above-  
a-14*  
mentioned examples of the support board 63 according to the fourteenth embodiment, together with the writing  
15 field 1 and transparent screen 6. In FIG. 33A, the support board 63 is provided between the writing field 1 and transparent screen 6, while, in FIG. 33B, the support board 63 is provided on the transparent sheet 6 opposite to the writing field 1. In each configuration,  
20 the support board 63 may be made of is a material having a sufficient structural strength to bear a force applied by a user in drawing an image on the writing field 1 by the pen 2 and a sufficient transparency, such as acrylic plate, a glass plate, etc. Further, in this  
25 configuration, when using a dispersion sheet 23 as

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provided in the above-mentioned twelfth or thirteenth embodiment, the dispersion sheet 23 may be preferably provided on the writing field 1 opposite to the user side.

5                   However, it is also possible that, as shown in FIG. 33C, the writing field 1 and transparent screen 6 are made of a common member (referred to as a writing-field transparent screen 64), in each of the above-mentioned embodiments. In such a case, as shown in FIG. 10 33C, it is preferable that a support board 63 is provided on the surface of the writing-field transparent screen 64 opposite to the user side, and, also, a dispersion sheet 23 can be inserted therebetween.

                  Since the other configurations and operations  
15 are the same as those of the first embodiment, duplicated description is omitted.

                  Further, the present invention is not limited to the above-described embodiments, and variations and modifications may be made without departing from the  
20 scope of the present invention.

                  The present application is based on Japanese priority applications. Nos. 2001-059321 and 2001-255119, filed on March 2, 2001 and August 24, 2001, respectively, the entire contents of which are hereby incorporated by  
25 reference.

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